

PROPOSED RE-CLASSIFICATION OF THE GENERA
MÜLLERIA AND HOLOTHURIA.

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(With one Plate.)

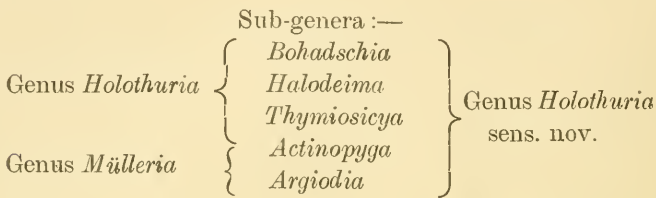
THE suggestions embodied in the present paper are the result of a careful examination of a large number of species of the genera *Mülleria* and *Holothuria*. These two genera are separated from each other by a single character, namely, the presence of anal teeth in the former and the absence of these structures in the latter. The only point in favour of this basis of classification is that it is convenient and simple. But taxonomic distinctions must necessarily be made in accordance with relationship, and there is good reason for believing that the accepted classification based upon the presence or absence of anal teeth gives no true conception of the affinities of this group. For example, the relationship between *Mülleria miliaris* and *Holothuria marmorata* is much closer than that between the latter species and *Holothuria impatiens* or than that between *Mülleria miliaris* and *Mülleria maculata*.

The affinities of the various species of the group are rendered much clearer by a systematic examination of the calcareous ring. This structure has never before received the attention it undoubtedly deserves, and one finds it dismissed with such statements as "typically Aspidochirote" or "without posterior prolongations." As a result of such a careful comparative study not only of the calcareous ring, but also of the other organs of the body, I have been impressed with the need for a more scientific classification than the one at present in vogue.

I propose to unite the genera *Mülleria* and *Holothuria* under the latter name, and to divide the genus into five sub-genera.

The genus *Holothuria*, as it is at present understood, will be composed of three sub-genera—(1) *Bohadschia*, to which such a form as *Holothuria marmorata* belongs; (2) *Halodeima*, which will include *Holothuria atra* and its allies; and (3) *Thymiosicya*, of which *Holothuria impatiens* may be regarded as the type. The genus *Mülleria* will be divided into two sub-genera—(1) *Actinopyga*, including such forms as *Mülleria miliaris*; and (2) *Argiodia*, to which *Mülleria maculata* and its allies belong.

Diagrammatically the proposed changes may be represented as follows :—



There are only four characters of any taxonomic value in the genus. These are (1) the arrangement of the ambulacral appendages; (2) the nature of the spicules; (3) the presence or absence of anal teeth; and (4) the structure of the calcareous ring. The number and arrangement of the tentacles, Polian vesicles, and stone canals are variable characters even within the limits of a single species. This is also true of the Cuvierian organs.

AMBULACRAL APPENDAGES.

The ambulacral appendages show considerable variation within the genus both as regards the kinds of appendages and also their distribution.

It is difficult to say whether any members of the genus are supplied with true pedicels only, although many authors have described such species, and Ludwig gives this character in his diagnosis of the genus *Holothuria*. Most workers at the group have not examined living specimens of the forms they

have described, and in many cases it is absolutely impossible to distinguish a true pedicel from a papilla, except in a living specimen. Many so-called pedicels have the appearance of a true pedicel, but they are not used by the animal as anchoring or locomotory organs. The distinction is easily seen in the living form, and I do not remember having seen a living Holothurian in which the dorsal appendages to any great extent had the power of attaching themselves to a foreign surface. The sub-genus *Bohadschia* is said by many authors to have true pedicels all over the body. After examining a living specimen of *Bohadschia vitiensis* I said: "The pedicels are irregularly scattered, and the sucking discs are apparently not well developed, since the animal does not appear to use them much."*

In many forms true pedicels are present on the trivium, and the bivium is covered with papillæ which may have a cylindrical shape and a well-developed sucking disc, or may be conical and may be devoid of sucking discs. In many cases true pedicels may be scattered among the dorsal papillæ.

Again, some species have no true pedicels, and these forms are more highly specialized than those which have pedicels on the trivium.

The absence or presence of pedicels appears a reliable means of separating the two sub-genera *Halodeima* and *Thymiosicya*.

NATURE OF THE SPICULES.

The spicules in the genus may consist in the simplest forms of dichotomously branched "rosettes." It is easy to conceive how these may give rise first to perforated plates and later to "buttons" and "tables." Those forms possessing tables and buttons may be regarded as more highly specialized than those in which the spicules are in the form of "dichotomous rods" and "rosettes."

* *Spolia Zeylanica*, Vol. IX., Part XXXIV., p. 59.

CALCAREOUS RING.

The primitive aspidochirote calcareous ring was composed of ten simple pieces (five radials and five inter-radials) without anterior or posterior prolongations (Pl. XXVI., fig. 1). The radial longitudinal muscles were attached to the radial pieces, and in consequence these were notched anteriorly for the insertion of the muscles, and because of this the radial pieces were larger and stronger than the inter-radials (Pl. XXVI., fig. 2). The tentacular ampullæ arose near the anterior end of the calcareous ring, and in consequence the anterior end of the ring became scooped out at twenty places (ampullary notches) corresponding to the twenty tentacles (Pl. XXVI., fig. 3). Such a type is seen in the sub-genera *Actinopyga* and *Bohadschia* (Pl. XXVI., figs. 4 and 5). In *Bohadschia vitiensis* the inter-radials do not project so far forward as the radials. This difference gradually becomes emphasized, and at the same time the ampullary notches become less and less marked, until in the sub-genera *Argiodia*, *Halodeima*, and *Thymiosicya* the ampullary notches are rarely clearly marked, and there is a marked difference between the radials and inter-radials in respect of the amount of anterior prolongation. Coupled with this we find that the anterior projections of the radials and inter-radials are clearly separated by a deep indentation (Pl. XXVI., figs. 6, 7, and 8).

ANAL TEETH.

The presence of anal teeth is not a primitive character, although the anus of the primitive Holothurian was probably pentagonal.* I am inclined to think that the appearance of the anus in *Bohadschia* is more primitive than the conditions in *Halodeima* and *Thymiosicya*. In the latter sub-genera the anus is generally rounded, and the papillæ are not grouped around it in any definite manner. In *Bohadschia* the anus is surrounded by five groups of papillæ, which give the anus a

* That is to say, in the contracted condition. In *Bohadschia vitiensis* the pulsating anus is alternately rounded and pentagonal during the conditions of diastole and systole, respectively.

five-rayed appearance in the contracted condition. It is not difficult to understand how these groups of papillæ may be converted first into eminences very richly provided with spicules, and later into five calcareous masses. The presence of anal teeth in *Actinopyga* and *Argiodia* does not necessarily point to a close relationship between the two sub-genera, and it is possible that in the group under discussion, as in some of the Dendrochirotae, these structures have little or no phyletic significance, and may have arisen independently in the two sub-genera.

AFFINITIES OF THE FIVE SUB-GENERA.

Taking these four characters and applying them to the five sub-genera, we find that with regard to the ambulacral appendages *Actinopyga* is the most primitive, since, with few exceptions, the pedicels are arranged in three rows on the trivium. In *Bohadschia*, which in other respects shows close affinities with *Actinopyga*, the pedicels are scattered over the trivium, with the notable exception of *Bohadschia græffei*. The species of the sub-genus *Bohadschia* are described by many as having pedicels all over the body. If such be the case, this would strengthen the claim of *Bohadschia* to be considered the most primitive member of the genus. *Thymiosicya*, with its complete lack of true pedicels, may be regarded as the most highly specialized.

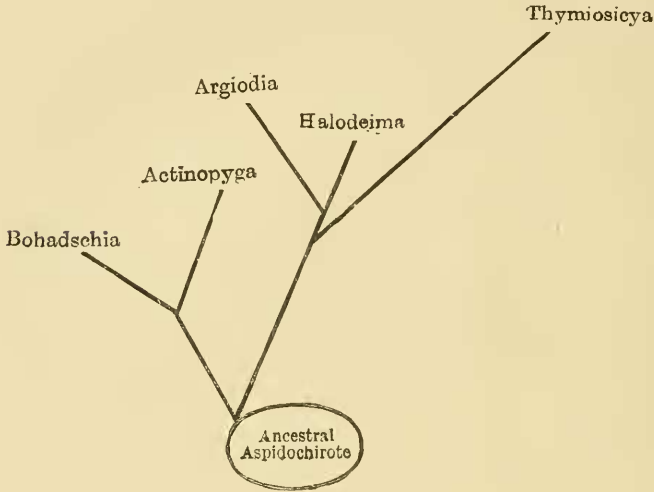
The evidence of the spicules points to *Actinopyga* and *Bohadschia* being the most primitive sub-genera, and also indicates their close relationship. The same conclusion is forced upon one by a comparative study of the calcareous ring.

I have already pointed out how the pentagonal anus of *Bohadschia* may be more primitive than the condition of things seen in the other sub-genera, and that the anal teeth of *Actinopyga* and *Argiodia* may be readily derived from the condition of things found in *Bohadschia*.

The weight of evidence goes to show that *Bohadschia* and *Actinopyga* are more closely related to each other than to the

other three sub-genera, and that *Bohadschia* is the more primitive form. The genera *Argiodia*, *Halodeima*, and *Thymiosicya* are united on the common ground of similarity of spicules and calcareous ring.

I show the relationship of the sub-genera in the following diagram :—



I give below the diagnoses of the genus and the sub-genera.

Genus HOLOTHURIA. Linn.

(= *Mülleria*, Jäger 1833 + *Holothuria*, Linn. 1758.)

Usually twenty peltate tentacles, exceptionally more or less. Ambulacral appendages, pedicels alone, papillæ alone, or with both. A single bundle of genital tubes on the left side of the dorsal mesentery. Calcareous ring without posterior prolongations or long retractor muscles. Cuvierian organs often present. Anal teeth sometimes present.

Sub-genus ACTINOPYGA.* Bronn.

(= *Actinopyga*, Bronn, 1860, partim; *Mülleria*,
Jäger, 1833, partim.)

Generally twenty tentacles, but occasionally more. Ambulacral appendages, papillæ on the bivium and pedicels on the trivium, the former being scattered and the latter being usually arranged in three more or less distinct rows. Anal teeth present. Calcareous ring has well-marked bevelled ampullary notches, and the anterior border has no deep indentations between the radials and inter-radials. The radials extend almost as far forward as the inter-radials. Spicules small, generally taking the form of dichotomously branched rods or spinous rods, or both. Tables and "buttons" never present.

Eight species :—

Actinopyga agassizi (Selenka), *Actinopyga echinites* (Jäger),
Actinopyga formosa (Selenka), *Actinopyga lecanora*
(Jäger), *Actinopyga mauritania* (Quoy & Gaimard),
Actinopyga miliaris (Quoy & Gaimard),
Actinopyga obesa (Selenka), *Actinopyga serratidens*,
(Pearson).

Sub-genus BOHADSCHIA.† Jäger.

(= *Bohadschia*, Jäger, 1833; *Holothuria*, Linn.
partim; *Sporadipus*, Brandt, 1835, partim.)

Twenty tentacles. Ambulacral appendages, pedicels, and papillæ. The trivium bears pedicels only, which are generally scattered, but which may be arranged in three rows. The bivium may bear either papillæ only, or papillæ mixed with pedicels (? or pedicels only). Anus surrounded by five groups of papillæ and in the contracted condition generally pentagonal in shape. Anal teeth absent. The calcareous ring closely

* This sub-genus is almost identical with Bronn's genus *Actinopyga*. I therefore retain this name.

† The sub-genus which I now establish for *H. marmorata* and the related forms is practically identical with Jäger's *Bohadschia*. I therefore propose re-establishing this name, which has long been discarded.

resembles that found in *Actinopyga*. Spicules in general similar to those of *Actinopyga*.

Five species :—

Bohadschia marmorata (Jäger), *Bohadschia argus* (Jäger),
Bohadschia vitiensis (Semper), *Bohadschia paradoxa*
(Selenka), *Bohadschia gräffeii* (Semper).

Sub-genus ARGIODIA.* Sub-gen. nov.

(= *Mülleria*, Jäger, 1833, partim; *Microthele*,
Brandt, 1835, partim.)

Twenty tentacles. Ambulacral appendages, papillæ on the bivium and pedicels on the trivium; no arrangement into rows discernible. Anal teeth present. Calcareous ring having no well-marked ampullary notches. The anterior border deeply concave between the radials and inter-radials. Spicules well-developed and consist of tables and buttons.

Four species :—

Argiodia maculata (Selenka), *Argiodia parvula* (Selenka),
Argiodia excellens (Ludwig), *Argiodia flavo-castanea*
(Théel).

Sub-genus HALODELMA.† Sub-gen. nov.

(= *Holothuria*, Linn. partim; *Microthele*, Brandt, 1835,
partim; *Sporadipus*, Brandt, 1835, partim;
Trepang, Jäger, 1833, partim;
Cystipus, Haacke, 1880.)

Generally twenty tentacles, occasionally more or less. Ambulacral appendages, papillæ on the bivium and pedicels on the trivium. Generally no arrangement into rows discernible. Anal teeth absent. Calcareous ring having no ampullary notches. The anterior border deeply concave between the radials and inter-radials. Spicules rarely perforated, plates only, or tables only. Generally tables and perforated plates or buttons.

* ἀργιόδους = with white teeth.

† ἅλδς = the sea; δειμα = monster.

This sub-genus contains a large number of species, of which *Halodeima atra* (Jäger) and *Halodeima monacaria* (Lesson) are representative.

Sub-genus THYMIOSICYA.* Sub-gen. nov.

(= *Holothuria*, Linn. partim ; *Fistularia*, Forskaal, 1775 ; *Trepang*, Jäger, 1833, partim.)

Twenty tentacles. Ambulacral appendages, papillæ only, which are often situated on wart-like eminences. Anal teeth absent. Calcareous ring similar to that of *Halodeima*. Spicules, tables, and buttons.

This sub-genus contains a large number of species, of which *Thymiosicya impatiens* (Forskaal) and *Thymiosicya spinifera* (Théel) may be said to be typical examples.

The following is a brief key to the sub-genera :—

A.—*Calcareous ring* with well-marked bevelled ampullary notches. The anterior border of the calcareous ring does not show the usual clear separation of radials from inter-radials. The inter-radials extend almost as far forward as the radials. *Spicules* small, and taking the form of dichotomously branched rods, or spinous rods, or both.

(a) With anal teeth.

..... *Actinopyga*.

(b) Without anal teeth.

..... *Bohadschia*.

B.—*Calcareous ring* without well-marked ampullary notches, and the anterior border is not bevelled. The anterior border of the calcareous ring deeply indented between the radials and inter-radials. The radials generally extending much further forward than the inter-radials. *Spicules* rarely consist of perforated plates, generally consist of tables and buttons.

* θυμίου = a wart ; σίκυς = cucumber.

- (a) With anal teeth.
 *Argiodia*.
- (b) Without anal teeth.
- (α) Pedicels on trivium. Papillæ on bivium.
 *Halodeima*.
- (β) True pedicels absent. Papillæ scattered
 all over the body. Generally on
 eminences.
 *Thymiosicya*.
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EXPLANATION OF PLATE XXVI.

Fig. 1.—Simplest form of calcareous ring consisting of five radials and five inter-radials. *i. r.* = inter-radial; *r.* = radial.

Fig. 2.—Simple form having an anterior notch in each radial, for the insertion of the radial muscle.

Fig. 3.—Simple form bearing ampullary notches: two complete notches and two half notches for each radial, and two half notches for each inter-radial. *a. n.* = ampullary notch.

Fig. 4.—Calcareous ring of *Actinopyga miliaris* (Quoy & Gaimard).

Fig. 5.—Calcareous ring of *Bohadschia vitiensis* (Semper).

Fig. 6.—Calcareous ring of *Argiodia maculata* (Brandt).

Fig. 7.—Calcareous ring of *Thymiosicya hamata* (Pearson).

Fig. 8.—Calcareous ring of *Halodeima vagabunda* (Selenka).
